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(71) Applicant
Motorola Limited

(Incorporated in the United Kingdom)

Jays Close, Viables Industrial Estate, Basingstoke, Hants, RG22 4PD, United Kingdom

(72) Inventors
Malcolm Perry
Andrew J Bracegirdle

(74) Agent and/or Address for Service
Hugh Christopher Dunlop
Motorola Limited, European Intellectual Property Operations, Jays Close, Viables Industrial Estate, Basingstoke, Hampshire, RG22 4PD, United Kingdom

# (54) Transistor mounting assembly

(57) The assembly comprises a power transistor 11, mounting means (e.g.a heat spreader 23) and a circuit board having an electrically conductive ground plane 22. Solder 26 is disposed between an edge of the transistor base plate terminal 11b and an edge of the circuit board ground plane 22. A clip 24 allows movement between the plane 22 and the copper heat spreader 23 during melting of the solder.

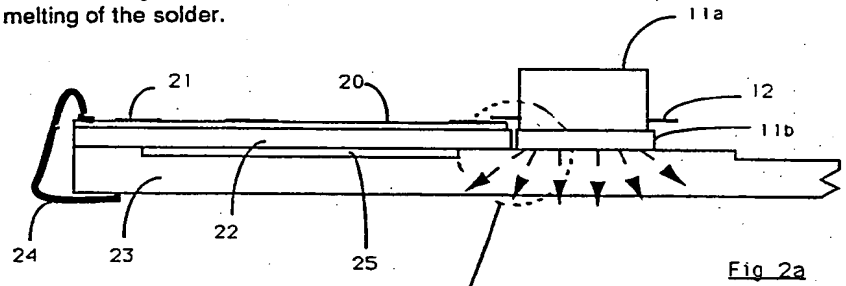


Fig 2a

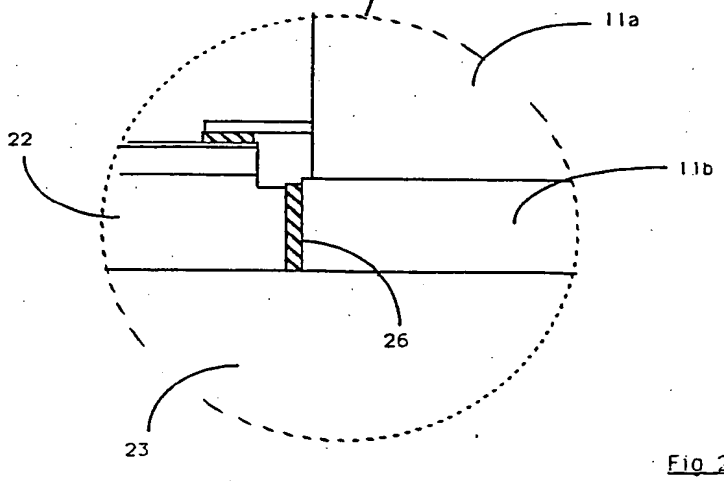


Fig 2b

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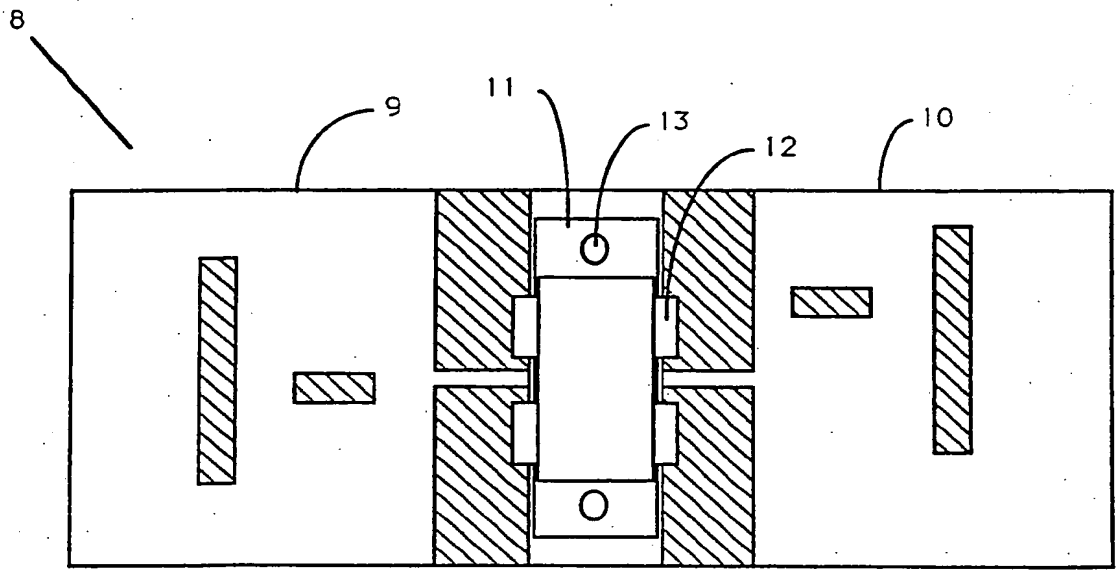


Fig. 1

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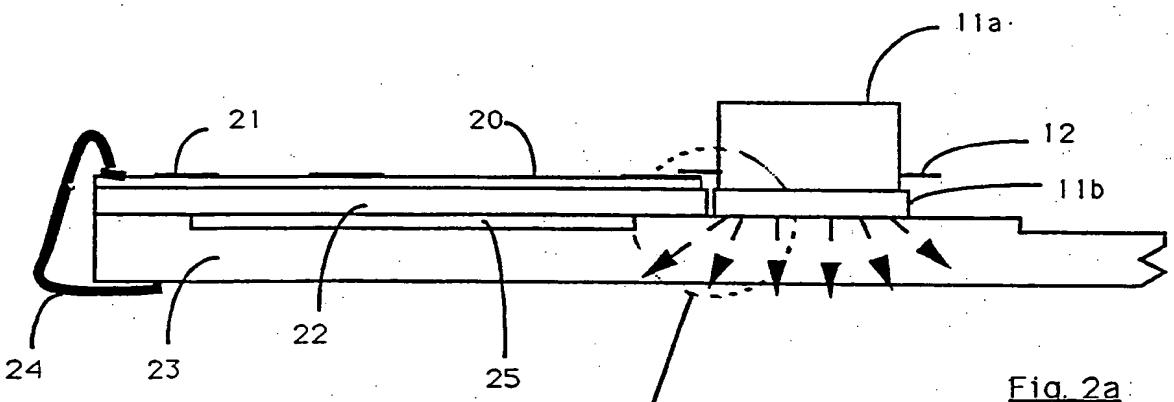


Fig. 2a

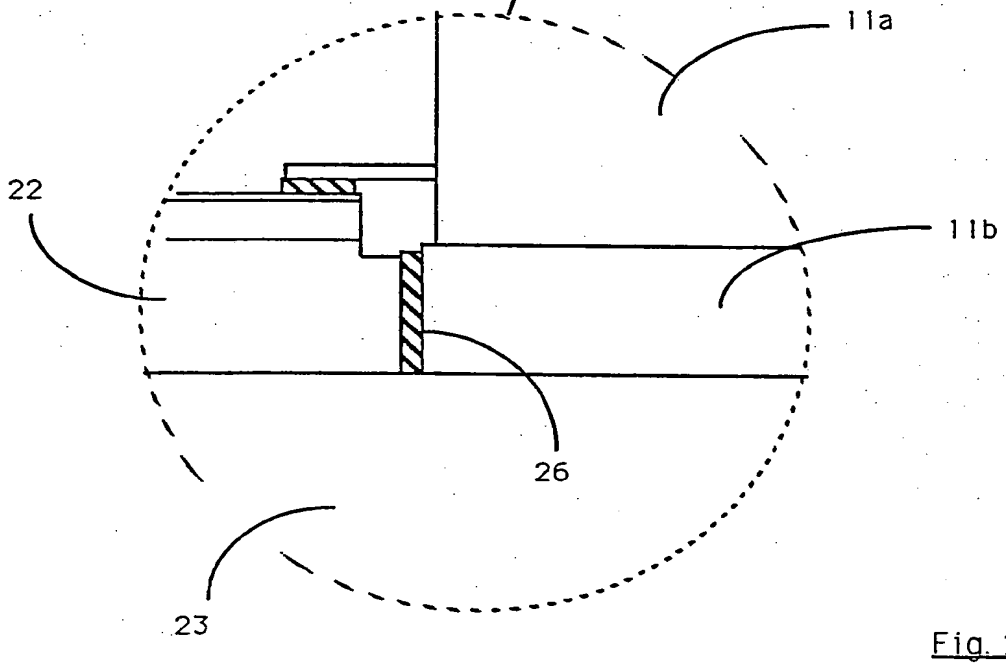


Fig. 2b

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# TRANSISTOR MOUNTING APPARATUS

## Background of the Invention

This invention relates to mounting apparatus for power transistors, for example RF power transistors.

## Summary of the Prior Art

In RF transmitters, output power transistors are used which generate substantial heat. Detailed consideration is needed to be given to dissipation of this heat away from the transistor. An integral transistor package for this purpose is the "gemini" form of package which comprises a ceramic upper part with connection pads projecting left and right therefrom and a metallic base plate with screw holes for screwing onto a heatsink. In these packages, the base plate is one of the terminals of the transistors.

When using the transistors for RF power application, in GSM cellular radio system, it is a problem that current flowing in and out of the transistor is conducted largely by the skin effect. This means that the electrical path from the base plate terminal of the transistor through the heatsink or other conductive medium on which it is mounted, to the electrical circuitry connected to the upper terminals is a long path in electrical terms. It is also a problem that there is contact resistance between the base plate terminal and the heatsink or other conductive medium on which it is mounted. A further problem is that the concentration of heat results in thermal stressing between contacts and circuit boards leading to early circuit failure.

There is a need for an improved mounting apparatus for use in these situations.

## Summary of the Invention

According to the invention there is provided transistor mounting apparatus comprising: a transistor having an electrically conductive base plate terminal and at least one other terminal, the base plate terminal having an edge of a predetermined thickness, mounting means (e.g. a heat spreader) for supporting said transistor, a circuit board for connecting to said other terminal, said circuit

board having an electrically conductive ground plane having an edge of substantially similar thickness to that of the base plate terminal of the transistor, the transistor and ground plane being mounted on the mounting means with their edges abutting and solder disposed between the abutting edges of the base plate terminal and the ground plane.

It is preferred that the circuit board is generally planar and restraining means are provided for restraining movement between the circuit board and the mounting means in a direction normal to the circuit board and allowing sliding movement between the circuit board and the mounting means in a direction parallel to the circuit board. The restraining means comprise a spring clip.

The ground plane of the circuit board may extend beyond the edge of the circuit board at its edge where it abuts the transistor.

The mounting means is preferably electrically conducting and heat conducting.

In the preferred embodiment, the mounting means has a generally planar surface on which the circuit board is mounted and at least one of the mounting means and the circuit board has a recessed portion defining a gap between the mounting means and the circuit board over a part of the planar surface, thereby assisting in free movement of the board relative to the mounting means.

According to the invention, a method of manufacture of transistor mounting apparatus is also provided, comprising the steps of: providing a transistor having an electrically conducting base plate terminal and at least one other terminal, the base plate terminal having an edge of a predetermined thickness; providing a circuit board for connecting to said other terminal, said circuit board having an electrically conductive ground plane having an edge of substantially similar thickness to that of the base plate of the transistor; applying solder to one of the edges of the base plate terminal and the ground plane; mounting the transistor and the ground plane on electrically conducting mounting means such that the edges abut together with the solder therebetween; and heating the solder causing it to join the base plate terminal and the ground plane.

A force may be applied to the base plate terminal and the ground plane, pressing them together while heating the solder. A jig

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may be provided to support the circuit board and transistor while applying said force.

Brief Description of the Drawings

Fig. 1 shows a plan view of a RF power module.

Figs. 2a and 2b show a cross section view of the module of Fig. 1 and an enlarged portion thereof.

Detailed Description of the Preferred Embodiment

Referring to Fig. 1, there is shown an assembly 8 comprising two circuit boards 9 and 10 having an RF power transistor 11 mounted therebetween. The transistor 11 has a "gemini" type casing. The shaded portions on the diagram represent copper plating on the circuit boards. The transistor 11 has four tabs 12 which are soldered to the copper plating on the surface of the boards and it has two screws 13 which assist in fastening the transistor to the assembly.

Referring to Fig. 2a, it can be seen that the assembly comprises a number of layers. The circuit board 9 comprises a PTFE layer with copper tracks 21 thereon defining r.f. matching circuitry (not shown, but readily implemented by one skilled in the art). The layer 20 lies on a copper ground plane 22 as a single piece. The board 9 is clamped onto a copper heatspreader and carrier 23 by means of a spring clip 24. The circuit board 10 is similar to circuit board 9. Copper is chosen for the tracks 21 and the ground plane because it is a good conductor of electricity and heat and is solder wettable.

The transistor 11 has a package formed of two parts - a ceramic upper part 11a and a metallic base plate 11b, which is one of the terminals of the transistor. The base plate is gold plated for good conduction, low oxidation and good solder wetting. The transistor generates a large amount of heat, which needs to be dissipated into the heatspreader 23 and this is represented by the dotted arrows radiating downwards from the transistor 11.

Referring to Fig. 2b, it is shown that there is a gap between the base plate 11b of the transistor and the ground plane 22 of the

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circuit board 9. In accordance with the invention, this gap is filled with solder 26.

The solder 26 provides three advantages:

1. It provides good electrical conductivity between the ground plane 22 of the circuit board and the base plate 11b of the transistor. This conductivity is much greater than is provided by the path from the transistor through the heatspreader 23 to the ground plane 22 because of the surface resistances between the base plate 11b and the heatspreader 23 and between the heatspreader 23 and the ground plane 22.

2. The solder reduces the length of the conductive path between the base plate 11b and the ground plane 22, since at RF frequencies of operation, conduction is largely by the surface effect and, without the solder 26, the conductive path would be that shown by the dotted arrow in Fig. 2b. This is a significant reduction in the conductive path.

3. The solder acts as a conductor of heat from the base plate 11b of the transistor to the ground plane 22.

The manufacture of the assembly 8 is as follows. The circuit board 9 (with its integral ground plane 22) is placed on the copper heatspreader and carrier 23. Solder paste 26 is spread along the edge of the ground plane 22 using a syringe. The transistor 11 is placed on the heatspreader and carrier 23 with the copper ground plane adjacent thereto. The second circuit board 10 is mounted on the copper heatspreader and base plate on the opposite side of the transistor. A horizontal force is now applied to each of the ground planes inwards towards the transistor 11, thus squeezing the paste in the gaps between the ground planes and the transistor. The assembly thus formed is mounted on a jig and subjected to infra-red reflow soldering or vapour phase reflow soldering. This causes the solder to melt and permanently form the joint between the transistor and the ground planes. In the solder process, electrical connections are made between the tabs 12 and the copper plating 21 on the circuit boards, in a manner readily understandable by one skilled in the art.

A significant advantage of the above arrangement is that the connection between the base plate 11b of the transistor and the ground plane 22 of the circuit board is substantially free of process

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tolerances. The clip 24 allows horizontal movement between the ground plane 22 and the heatspreader and carrier 23, resulting from thermal expansion, thereby reducing thermal stress.

It can be noted in Fig. 2b that the ground plane 22 of the circuit board 20 extends beyond the circuit board in the direction of the transistor 11. This prevents the solder 26 from wicking upwards onto the copper track 21 on the surface of the circuit board 20.

A gap 25 is milled out of the heatspreader 23 in areas not critical for heat transfer or clip fastening. This fulfils two functions: (i) reduction in thermal mass of the assembly, as a manufacturing aid and (ii) provision of a channel for solvents to remove solder flux residues to allow free movement of the boards 9 and 10 against the pressure of the clips 24. This movement reduces the differential expansion between the device tabs 12 and the copper tracking 21 on the circuit boards 9 and 10.

Apparatus has been described which provides a very low impedance interface for signals comprising high currents in the 900MHz band, between a power amplification device and its associated matching circuitry.

The operating life of the circuit is substantially lengthened by the removal of the most common failure mechanism, namely the thermally induced cracking in the solder joint between the device tabs and the circuit board tracking.

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## Claims

1. Transistor mounting apparatus comprising:

a transistor having an electrically conducting base plate terminal and at least one other terminal, the base plate terminal having an edge of a predetermined thickness,

mounting means for supporting said transistor,

a circuit board for connecting to said other terminal, said circuit board having an electrically conducting ground plane having an edge of substantially similar thickness to that of the base plate terminal of the transistor, the transistor and ground plane being mounted on the mounting means with their edges abutting and

solder disposed between the abutting edges of the base plate terminal and the ground plane.

2. Apparatus according to claim 1 wherein the circuit board defines r.f. matching circuitry.

3. Apparatus according to claim 1 or 2 wherein the ground plane of the circuit board extends beyond the edge of the circuit board at its edge where it abuts the transistor.

4. Apparatus according to any one of claims 1 to 3, wherein the mounting means is electrically conducting and heat conducting.

5. Apparatus according to any one of the preceding claims wherein the circuit board is generally planar and restraining means are provided for restraining movement between the circuit board and the mounting means in a direction normal to the circuit board and allowing sliding movement between the the circuit board and the mounting means in a direction parallel to the circuit board.

6. Apparatus according to claim 5 wherein the restraining means comprise spring fastening means.

7. Apparatus according to claim 5 or 6, wherein the mounting means has a generally planar surface on which the circuit board is

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mounted and at least one of the mounting means and the circuit board has a recessed portion defining a gap between the mounting means and the circuit board over a part of said planar surface, thereby assisting in free movement of the board relative to the mounting means.

8. A method of manufacture of transistor mounting apparatus comprising the steps of:

providing a transistor having an electrically conducting base plate terminal and at least one other terminal, the base plate terminal having an edge of a predetermined thickness;

providing a circuit board for connecting to said other terminal, said circuit board having an electrically conductive ground plane having an edge of substantially similar thickness to that of the base plate of the transistor;

applying solder to one of the edges of the base plate terminal and the ground plane;

mounting the transistor and the ground plane on electrically conducting mounting means such that the edges abut together with the solder therebetween; and

heating the solder causing it to join the base plate terminal and the ground plane.

9 A method according to claim 8 comprising the step of applying a force to the base plate terminal and the ground plane, pressing them together while heating the solder.

10. A method according to claim 9 comprising the step of providing a jig to support the circuit board and transistor while applying said force.

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**Patents Act 1977**
**Examiner's report to the Comptroller under Section 17 (The Search Report)**

Application number

9117300.5

**Relevant Technical fields**

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H1R (RBK)

(ii) Int Cl (Edition 5 ) H01L, H05K

Search Examiner

C D STONE

**Databases** (see over)

(i) UK Patent Office

(ii)

Date of Search

17 DECEMBER 1991

Documents considered relevant following a search in respect of claims ALL

| Category (see over) | Identity of document and relevant passages | Relevant to claim(s) |
|---|---|---|
| X | US 4736273 PHILIPS<br>See figure 4 | 1,8 |

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| Category | Identity of document and relevant passages | Relevant to claim(s) |
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